

Zambia - Integrated Land Use Assessment Phase 2, 2016

**Forestry Department, Zambia, Ministry of Lands, Natural Resources and
Environmental Protection**

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Identification

SURVEY ID NUMBER

ZMB_2016_ILUA_P2_v01_M_v01_A_ESS

TITLE

Integrated Land Use Assessment Phase 2, 2016

ABBREVIATION OR ACRONYM

" ILUA II" as Integrated land Use Assessment Phase Two

COUNTRY

Name	Country code
Zambia	ZMB

STUDY TYPE

Forest resource survey

SERIES INFORMATION

The first national forest inventory (NFI) in Zambia, was conducted between 1932 and 1936 in the Miombo woodlands, focusing on timber availability for the mining sector. Subsequent inventories followed in 1942–44 and 1949–51, targeting the Copperbelt and Western Provinces for industrial and concession-based timber extraction.

Between 1952 and 1967, a large-scale forest inventory was carried out nationwide, resulting in the compilation of District Management Books (DMBs), which served as foundational datasets for subsequent assessments. These early efforts were largely timber-focused and region-specific.

In the 1980s and 1990s, Zambia undertook more comprehensive assessments. The 1986 National Wood Energy Consumption and Resource Survey estimated national woody biomass between 3.0 and 4.1 billion m³, while the SADC Wood Energy Study (1987) provided a regional comparative baseline.

Later efforts included the Provincial Forestry Action Programme (PFAP) assessments from 1996–2001, and the Forestry Support Programme (FSP) from 2002–2004, which introduced stratified random sampling and provincial-level reporting. The Integrated Land Use Assessment Phase I (ILUA I) conducted from 2005 to 2008 marked a turning point in Zambia's forest monitoring system. It was the first multi-sectoral assessment combining biophysical and socio-economic data across all nine provinces at that time. ILUA I laid the methodological and institutional foundation for the more refined ILUA II.

ABSTRACT

The Integrated Land Use Assessment Phase II (ILUA II) is Zambia's most extensive national effort to date in forest and land use monitoring. Implemented from 2010 to 2016 by the Forestry Department under the Ministry of Lands and Natural Resources — with technical support from the Food and Agriculture Organization of the United Nations and funding from the Government of Finland — ILUA II aimed to strengthen forest resource management and enhance its contribution to sustainable development.

The assessment employed a two-stage stratified sampling design, resulting in 1093 clusters and 4372 permanent sample plots established across Zambia's ten provinces. Data were collected on a wide range of variables including tree species composition, regeneration, deadwood, soil, disturbances, canopy cover, land use, and forest-dependent livelihoods. The sampling framework was aligned with FAO's Forest Resource Assessment (FRA) land cover strata: Forest, Other Wooded Land, and Other Land.

Remote sensing using Landsat 5, 7, and 8 was applied to generate forest cover maps for 2000, 2010, and 2014. This supported accurate estimation of deforestation rates and land cover transitions. Field and spatial data were managed using Open Foris Collect and analyzed through Open Foris Calc.

ILUA II provides statistically robust estimates for biomass, carbon stock, and forest area, and serves as a cornerstone for Zambia's REDD+ Measurement, Reporting and Verification (MRV) system, national reporting — FRA, United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD) — and sustainable forest policy development.

KIND OF DATA

Sample survey data [ssd]

UNIT OF ANALYSIS

Fields/Plots

Scope

NOTES

The scope of ILUA II extends across ecological, biophysical, and socio-economic dimensions, with information collected from permanent sample plots. The assessment produced detailed information on forest extent and type, land cover dynamics, vegetation structure, tree species diversity, different levels of biomass and carbon stock estimates, forest degradation signs, regeneration potential, and soil characteristics. Remote sensing complemented fieldwork by quantifying land use and forest cover changes over three time points: 2000, 2010, and 2014.

In addition, ILUA II addressed socio-economic dependencies on forests, forest tenure systems, and biodiversity conditions.

Key highlights included:

- Miombo woodlands dominate Zambia's forest landscape;
- Deforestation remains driven by charcoal production and agriculture;
- Species diversity varies widely across forest types.

The assessment further revealed that significant carbon stocks are held in forest biomass, but pressures on resources remain high due to weak enforcement and limited alternative livelihoods.

TOPICS

Topic
Forest Resource Assessment

KEYWORDS

Keyword
National Forest Inventory
Forest Resources Assessment
Forest Monitoring
Land Use Change Monitoring
Biomass
Carbon Stock Estimation

Coverage

GEOGRAPHIC COVERAGE

National

UNIVERSE

The target population of the assessment comprises all land areas within the territory of Zambia that fall under one of three land use strata: Forest, Other Wooded Land, and Other Land, as defined by the FRA classification. The universe includes natural and planted forests, wooded shrublands, open and closed canopy formations, and non-forest areas that contribute to national land use dynamics and carbon accounting.

The survey excluded areas that were permanently converted to non-vegetative use, such as urban centers, industrial facilities, water bodies, or heavily degraded zones without vegetation. In addition, small-fragmented areas under 0.5 hectares that did not meet the FAO minimum mapping unit for forest or wooded land were excluded. The sampling frame also deliberately omitted areas with no significance to forest monitoring, biomass estimation, or land use transition.

Producers and sponsors

PRIMARY INVESTIGATORS

Name	Affiliation
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Forestry Department, Zambia	Government of Zambia
Ministry of Lands, Natural Resources and Environmental Protection	Government of Zambia

PRODUCERS

Name	Abbreviation
Food and Agriculture Organization of the United Nations	FAO
Centre for International Forestry Research	CIFOR
Central Statistical Office	CSO
Copperbelt University	CBU
Department of National Parks and Wildlife	DNPW
Ministry of Agriculture and Livestock	MAL
Ministry of Finance and National Planning	MOFNP
National Institute for Scientific and Industrial Research	NISIR
National Remote Sensing Centre	NRSC
Survey Department	SD
University of Zambia	UNZA
Zambia Agriculture Research Institute	ZARI
Zambian Environmental Management Agency	ZEMA
Zambia Forestry College	ZFC
Zambia Forestry and Forest Industries Corporation	ZAFFICO

FUNDING AGENCY/SPONSOR

Name
Finnish Government

Sampling

SAMPLING PROCEDURE

ILUA II utilized a two-stage stratified sampling design across all ten provinces of Zambia to achieve national coverage and represent forest diversity across Zambia's ecological and administrative regions.

The three land use strata used were: Forest, Other Wooded Land, and Other Land.

Stage 1 involved a systematic grid-based remote assessment of 6283 georeferenced points, each spaced at 0.1-degree intervals (~10 km apart), analyzed using FAO's Collect Earth tool overlaid with high-resolution satellite imagery. Each 1-hectare grid square included 25 observation points to evaluate tree canopy cover, dominant land use/cover, and vegetation classification. These points were categorized into eight land cover classes, ranging from dense forest and plantations to grasslands and cropland, forming the basis for stratification.

Stage 2 involved selecting a subsample of first-stage points for full field enumeration. The selection was guided by three principles: inclusion of ILUA I legacy plots, adequate provincial representation, and full coverage of forest types and conditions. A simulation approach was used to optimize sampling distribution, minimizing variance within classes. The final design included 1084 field clusters, containing 4348 main sample plots and 13 044 subplots, across all ten provinces.

Each cluster consisted of four rectangular plots measuring 20 m x 50 m (0.1 hectares), arranged systematically. The data collection within plots followed a multi-level structure:

- Main Plot (0.1 ha): All trees greater than or equal to 10 cm Diameter at Breast Height (DBH) were measured, including variables such as species, diameter, height, and use (timber, fuel, etc.).

- Subplot (0.02 ha, within main plot): Saplings between 5-9.9 cm DBH were measured using a concentric nested plot approach.
- Regeneration Plot (radius 3.99 m): Located inside each subplot, where all tree seedlings less than 5 cm DBH were counted and classified.
- Soil Sampling (subset of clusters): In Plot 1 only, three soil types were collected:
 - o Undisturbed core samples (0-30 cm depth in 3 layers)
 - o Disturbed samples for organic soil carbon
 - o Composite samples from five points (center + 4 cardinal directions)
- Litter Quadrant (0.25 m²): Thrown randomly in Plot 1 of soil clusters to collect dry litter (grass, leaves, twigs) for biomass estimation.
- Disc Pasture Samples: Ten additional disc meter samples per cluster were collected to estimate standing grass biomass.

All observations, including land use, legal status, forest services, and proposed management actions, were systematically recorded in each plot location.

DEVIATIONS FROM THE SAMPLE DESIGN

ILUA II covered all 1084 clusters and 4348 main sample plots as planned. However, minor deviations occurred where certain plots were inaccessible due to physical barriers or land use changes. In such cases, plot locations were adjusted nearby following field protocols, and all adjustments were recorded with GPS and incorporated into spatial analysis. Where full measurement was not possible, land use and vegetation data (LUVS) were still collected to retain classification consistency. The number of sampling units with deviations are not reported exclusively.

RESPONSE RATE

A total of 1084 clusters and 4348 main sample plots were targeted for biophysical data collection across Zambia's ten provinces. All clusters were attempted and assessed as reported, and there is no indication of widespread non-response or systematic exclusion.

In isolated cases, physical inaccessibility, such as rugged terrain, flooding, or land conversion, affected the ability to fully measure certain plots. When this occurred, enumerators followed pre-defined protocols to record land use and vegetation section (LUVS) data and, where possible, relocated plots slightly to nearby suitable locations. These adjustments were recorded and included in spatial processing, but the number of adjusted plots is not mentioned exclusively.

A numerical response rate is not explicitly stated in the report, but the documentation consistently refers to successful field coverage of the full sample frame, suggesting a high effective response rate approximating 100% at the cluster level. All collected data were subject to centralized quality control and verification by supervisory teams.

WEIGHTING

ILUA II applied stratified weighting approaches to scale sample data to national estimates, accounting for both biophysical and socio-economic components.

For bio-physical components, weighting was based on land cover strata (Forest, Other Wooded Land, and Other Land), using area-adjusted expansion factors. Each plot observation was assigned a weight representing the area it covered within its stratum. These expansion factors allowed results to be aggregated from plot level to national level estimates for biomass, carbon stock, and forest area. Data processing was carried out using Open Foris Calc.

For deforestation estimates, a Stratified Area Estimator (SEA) was applied to correct classification bias in land cover maps, resulting in a nationally weighted deforestation rate of 276 021 ha/year, consistent with Zambia's Forest Livelihood Economic Survey (FREL) submission.

The socio-economic component's data were weighted using 2010 Census benchmarks. A total of 5040 households from 252 SEAs were weighted up with an estimate of 2.51 million households nationally. Households were categorized into four groups based on their engagement with forest products, with different sampling weights applied to ensure representativeness across use types and forest cover gradients.

SPSS and Excel were used for weighting and analysis.

Data collection

DATES OF DATA COLLECTION

Start	End
2010	2016

DATA COLLECTION MODE

Field measurement

Data Processing

DATA EDITING

ILUA II followed a structured and multi-layered data cleaning and editing approach for biophysical, socio-economic (Forestry Livelihoods Economic Survey, FLES), and soil/litter sampling.

- Biophysical Data:

Data collected in the field was first reviewed by the Field Coordination/Quality Assurance Supervisors (FC/QAS), who validated paper forms and supervised the transition of data to the Project Management Unit (PMU). The Quality Assurance (QA) teams performed control re-measurements on Plot 1 of selected clusters and provided feedback to field teams to correct systematic errors. A QA checklist and control booklet was maintained for each visited cluster.

Once validated, the data were digitized and cleaned using Open Foris Collect, with technical validation rules embedded during entry. Final computations and consistency checks were completed using Open Foris Calc, where additional R scripts are used for estimating integrity.

- Socioeconomic Data:

FLES data were recorded by enumerators from the Central Statistical Office (CSO) and entered in SPSS (version 22). Cleaning steps included manual and automated consistency checks, non-response tagging, skip logic validation, and structural harmonization. Final tables were exported to MS Excel for post-processing and graphics development. CSO supervised all cleaning activities to align with national statistical protocols.

- Soil and Litter Data:

Soil and litter samples were tracked from field collection to laboratory analysis under the supervision of a dedicated Soil Survey and Analysis Coordinator. A sample ledger was maintained at the Forest Research Station in Kitwe, where laboratory data entry into Open Foris Collect was followed by cross-checking for sample matching, completeness, and standard adherence. Monthly and terminal QA reports were produced for FAO and the Forestry Department.

Data Appraisal

ESTIMATES OF SAMPLING ERROR

Statistical methods were applied to estimate sampling errors and quantify the reliability of land area and biomass estimates. The approach followed is outlined in Tomppo & Andersson (FAO, 2008) and Olofsson et al. (2014), which were adapted to Zambia's stratified sampling design.

- Calculation Method:

The standard error (SE) was computed as the square root of the variance of estimates for each stratum. The relative sampling error was then derived by dividing the SE by the stratum mean and multiplying by 100. Estimates were aggregated using area-weighting formulas to produce national totals. A Student's t-value at 95% probability level was applied to calculate confidence intervals.

- National Forest Area Estimates:

The sampling error for forest land was estimated at 1.4%, corresponding to $\pm 606,812$ hectares, and the 95% confidence interval extended up to 1.19 million hectares. This indicates a high level of precision in extrapolating sample-based forest area estimates to national levels.

- Provincial-Level Errors:

Sampling errors at the provincial level ranged from 2.7% to 6.8% for forest land, depending on variability and sample density, with a maximum sampling error of 1.19 million ha. For instance, Lusaka Province had the highest forest land sampling error at 6.8%, while North-Western Province had the lowest at 2.7%.

DATA APPRAISAL

In addition to sampling error, ILUA II applied other data appraisal techniques to assess statistical reliability, minimize bias and reduce non-sampling errors:

- Response and Interviewer Bias (FLES): The FLES Manual provided enumerator protocols to minimize interviewer influence and response distortion, including use of neutral probes, scripted phrasing, and training against biased questioning.

- **Land Cover Accuracy Assessment:** Stratified area estimator methods were used to correct classification bias in land cover maps (2000, 2010, 2014). Accuracy metrics included user and producer accuracy and Kappa coefficients, which exceeded 0.80, indicating high classification reliability.
- **Model-Based Biomass Error Testing:** Biomass model evaluations included Residual Standard Error (RSE), R^2 , and Shapiro-Wilk tests to detect bias and validate model fit across forest types.

Access policy

CONFIDENTIALITY

The confidentiality conditions will be based on the external repository, owned by the country.

ACCESS CONDITIONS

Data available on an external repository. The access conditions will be based on the external repository, owned by the country.

CITATION REQUIREMENTS

Use of any content requires acknowledgment and citation and will follow the conditions set in the external repository by the country.

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Metadata production

DDI DOCUMENT ID

DDI_ZMB_2016_ILUA_P2_v01_M_v01_A_ESS_FAO

PRODUCERS

Name	Abbreviation	Affiliation	Role
Statistics Division	ESS	Food and Agriculture Organization of the United Nations	Metadata producer

Data Dictionary

Data file	Cases	Variables
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